

WHAT WE CLAIM ARE:

1. A semiconductor device manufacture method comprising steps of:

(a1) forming an insulating film made of zirconia or hafnia over a surface of a semiconductor substrate;

5 (a2) covering a partial surface area of the insulating film with a mask pattern;

(a3) by using the mask pattern as a mask, implanting ions into a region of the insulating film not covered with the mask pattern to give damages to the insulating film; and

10 (a4) by using the mask pattern as a mask, etching a portion of the insulating film.

2. A semiconductor device manufacture method according to claim 1, wherein the step (a3) implants ions into the insulating film, the ions being ions of an 15 element not generating carriers when the ions are implanted into the semiconductor substrate.

3. A semiconductor device manufacture method according to claim 1, wherein the step (a3) implants ions into the insulating film, the ions being ions of an 20 element selected from a group consisting of silicon, germanium, argon and xenon.

4. A semiconductor device manufacture method according to claim 1, wherein the step (a4) etches the insulating film by using sulfuric acid or mixture liquid of sulfuric acid and hydrogen peroxide.

5. A semiconductor device manufacture method according to claim 2, wherein the step (a4) etches the insulating film by using sulfuric acid or mixture liquid of sulfuric acid and hydrogen peroxide.

5 6. A semiconductor device manufacture method according to claim 3, wherein the step (a4) etches the insulating film by using sulfuric acid or mixture liquid of sulfuric acid and hydrogen peroxide.

7. A semiconductor device manufacture method comprising steps of:

10 (b1) forming an insulating film made of zirconia or hafnia over a surface of a semiconductor substrate;

(b2) covering a partial surface area of the insulating film with a mask pattern;

(b3) by using the mask pattern as a mask, transforming a region of the insulating film not covered with the mask pattern to an amorphous state; and  
15 (b4) by using the mask pattern as a mask, etching the insulating film transformed to the amorphous state.

8. A semiconductor device manufacture method comprising steps of:

20 (c1) forming an insulating film made of zirconia or hafnia over a surface of a semiconductor substrate;

(c2) covering a partial surface area of the insulating film with a mask pattern;

(c3) by using the mask pattern as a mask, exposing a region of the insulating film not covered with the mask pattern to one plasma selected from a  
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group consisting of nitrogen plasma, argon plasma and ammonia plasma; and  
(c4) by using the mask pattern as a mask, etching a portion of the insulating film.

5 9. A semiconductor device manufacture method according to claim 8, wherein the step (c4) etches the insulating film by using one etchant selected from a group consisting of sulfuric acid, mixture liquid of sulfuric acid and hydrogen peroxide, fluoric acid and phosphorous acid.

10 10. A semiconductor device manufacture method comprising steps of:  
forming an insulating film made of zirconia or hafnia over a surface of a semiconductor substrate;  
forming a gate electrode on a partial surface area of the insulating film;  
15 by using the gate electrode as a mask, implanting ions into a region of the insulating film not covered with the gate electrode to give damages to the insulating film;  
by using the gate electrode as a mask, etching a portion of the gate insulating film; and  
20 by using the gate electrode as a mask, implanting impurity ions into a surface layer of the semiconductor substrate on both sides of the gate electrode.

11. A semiconductor device manufacture method comprising steps of:  
25 forming an insulating film made of zirconia or hafnia over a surface

- of a semiconductor substrate;
- forming a gate electrode on a partial surface area of the insulating film;
- by using the gate electrode as a mask, exposing a region of the
- 5 insulating film not covered with the gate electrode to one plasma selected from a group consisting of nitrogen plasma, argon plasma and ammonia plasma;
- by using the gate electrode as a mask, etching a portion of the gate insulating film; and
- by using the gate electrode as a mask, implanting impurity ions into
- 10 a surface layer of the semiconductor substrate on both sides of the gate electrode.

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